Netto (L.) Le Muséum National de Rio de Janeiro et son Influence sur les Sciences Naturelles en Brésil. 8vo. *Paris* 1889. The Author.

Phillimore (W. P. W.) The Dictionary of Medical Specialists. 8vo. *London* 1889. The Editor.

Pickard-Cambridge (Rev. O.), F.R.S. The Spiders of Dorset. 8vo. *Sherborne* 1879–1881. With four Supplementary Papers. 8vo. *Sherborne* 1882–1889; Monograph of the British Phalangidea or Harvest-Men. 8vo. *Dorchester* 1890. The Author.

Roberts-Austen (W. C.), F.R.S. An Introduction to the Study of Metallurgy. 8vo. *London* 1891. The Author.

May 14, 1891.

Sir WILLIAM THOMSON, D.C.L., LL.D., President, in the Chair.

The Presents received were laid on the table, and thanks ordered for them.

In pursuance of the Statutes the names of the Candidates recommended for election into the Society were read from the Chair as follows:—

Anderson, William.
Bower, Prof. Frederick Orpen, D.Sc.
Conroy, Sir John, Bart., M.A.
Cunningham, Prof. Daniel John, M.D.
Dawson, George Mercer, D.Sc.
Elliott, Edwin Bailey, M.A.
Frankland, Prof. Percy Faraday, B.Sc.
Gilchrist, Percy C.
Halliburton, William Dobinson, M.D.
Heaviside, Oliver.
Marr, John Edward, M.A.
Mond, Ludwig.
Shaw, William Napier, M.A.
Thompson, Professor Silvanus Phillips, D.Sc.
Tizard, Capt. Thomas Henry, R.N.

The following Papers were read:—

I. "On the Examination for Colour of Cases of Tobacco Scotoma, and of Abnormal Colour Blindness." By Captain W. de W. ABNEY, C.B., R.E., D.C.L., F.R.S. Received April 29, 1891.

The following cases were submitted to the Colour Vision Committee, and it was thought desirable that the results of the examination should be communicated to the Royal Society.

The examination of these three cases was conducted at different times, the first partially in the presence of the Colour Vision Committee by Mr. Nettleship, and the two last, and part of the examination of the first, at different times, in my laboratory, with the assistance of Mr. Nettleship.

In all three cases the examination made was an ability to distinguish colour, luminosity of the different parts of the spectrum, and total sensation of light; and, in addition, in the first case, to range of colour sensation on the retina.

Case I.—This patient, Alfred C., aged 36, a traveller, was suffering from rather severe tobacco amblyopia, and was brought to the Committee by Mr. Nettleship. The scotoma was a very marked one, and the loss of colour sensation most complete. Mr. Nettleship has kindly added the following remarks on the case:—

His acuteness of vision was $\frac{6}{36}$ with R. and $\frac{6}{60}$ with L. He smoked half-an-ounce of "shag" daily and drank about four pints of beer. His sight had been failing for about two months. As is common in early stages of this disease, the ophthalmoscope revealed no decided changes at the optic discs.

He was tested at the Royal Institution by Mr. Nettleship, in the presence of the Committee, with the following results:—

He passed the test of the Holmgren wools satisfactorily, proving that the usual vision was normal for colour. I had prepared small pellets of moulder's clay, each weighing 4 grains, and about $\frac{1}{5}$ inch in diameter, and had had sets coloured with the same colours as those of the Holmgren wools. C. was told to pick out the blues, reds, and greens. The blue pellets he picked out without fail, and he never made the least mistake in his choice, but he failed entirely to distinguish the greens or reds, mistaking them for drabs and greys, which were amongst the pellets. When told to look away some 20° from the slab on which the pellets were placed, he at once saw all the colours, but directly he turned his eyes to pick them out, all colour perception, except for blue, disappeared. This test indicated that he had lost all perception of green and red in the central part of the eye. He was next tested with small discs of different colours by Mr. Nettleship, keeping his eye fixed on a given point, and the loss of colour sensation for all except blue, and perhaps a little yellow, in the central part of the eye, was at once made apparent; the blue he would distinguish with the greatest facility, and the sensation was apparently as strong as in normal eyesight. A further test was made by Mr. Nettleship with coloured lights to imitate signal lights, and he named a brilliant red light, and an equally brilliant green light, when side by side, both as white (see also p. 85).

This man attended at my laboratory, at the meeting of the Committee on Colour Vision, with Mr. Nettleship, and he was tested with

the colour-patch apparatus described in "Colour Photometry," in the 'Philosophical Transactions,' 1886, by General Festing and myself. The objects first in view were to test his perception of the spectrum colours, and then his retinal field colour perception for the same. A template was cut out after the manner described by General Festing and myself in the second part of "Colour Photometry" ('Phil. Trans.,' 1889), of such a shape that all the spectrum lying between λ 4600 and λ 6600 was reduced to equal luminosity when it was rotated in front of the spectrum. Diaphragms containing holes of different sizes were placed in front of the last prism, and thus a round spot of monochromatic light of the same luminosity was produced upon the screen when a slit was passed through the spectrum. From the red end to λ 5270 he called the whole of the colours white, and from that point he began to see blue, called the colours bluish and blue. When the full illumination for all the colours was used, the same results were obtained. From this examination it would appear that he was totally deprived of the sensation of any colour except of blue. A subsequent examination of his perception of the luminosity of different rays, however, has to be taken into account, for in the first examination he had no light of pure white with which to compare the colours. In the next experiments, a strip of white light was

I.	II.	III.	IV.	V.	Remarks.
Scale No.	Wave-length.	Luminosity to the normal eye.	Luminosity to X.	$\frac{\text{IV.}}{\text{III.}}$	
60	6730	7·3	0	0	Sees only the white stripe.
57	6423	32	10	0·31	Calls red yellowish, and white bluish.
55	6242	65	38	0·65	,, ,, ,,
53	6074	96	86	0·89	Both one colour.
51	5920	99	90	0·91	,, ,,
47	5660	92	83	0·90	Calls green a little blue; white he sees as white.
43	5430	69	625	0·90	,, ,, ,
40	5270	50	46	0·92	,, ,, ,,
32	4910	8·5	9	1·06	Sees blue as blue, and white yellowish.
31	4960	7	8	1·14	,, ,, ,,
26	4680	3	3	1·00	,, ,, ,,

placed in juxtaposition to the colour, and the results were slightly different. The table (p. 493) gives his luminosity measures. Col. I is the empyric scale number, II is the wave-length, III the luminosity of the colour to the normal eye, IV the luminosity to C, and V the ratios of III to IV.

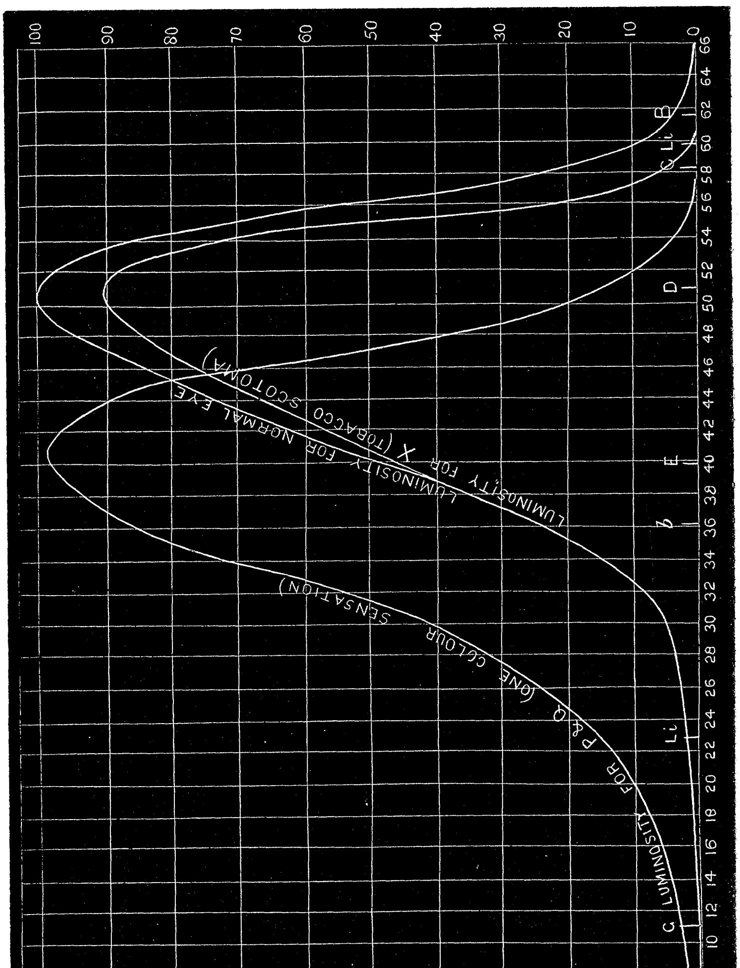


FIG. 1.

In the diagram, his luminosity curve X is shown, its area being 1400 against 1650 for the normal eye. As will be shown, his perception of light is only two-thirds of that of the normal eye; hence

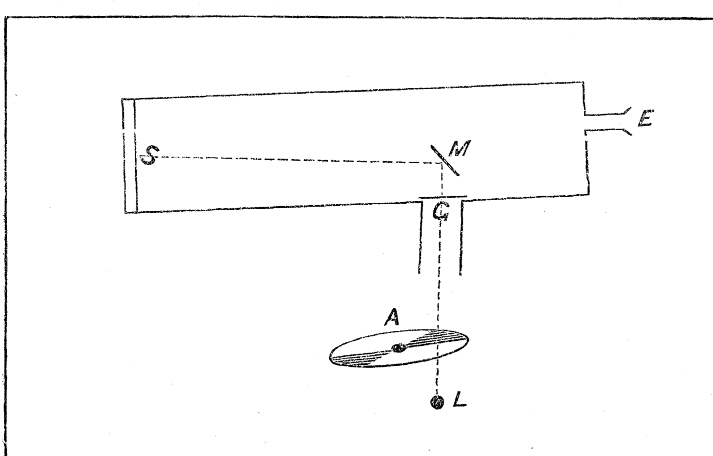
his area of luminosity should be 1100. As it is 1400, the ordinates of the above curve should be multiplied by 0·8, to compare with that of the normal eye.

It should be mentioned that his matches of luminosity were made without any hesitation, and were concordant for each observation, which is not to be wondered at, as the matches, except at the blue end, were practically matching shades of black to white.

From the foregoing, it will be seen that the white which C. sees as white is the same as the D sodium light, and that the red he says is yellowish. The mixture of this yellowish-white with the blue apparent makes white at λ 5430. He sees a little blue in the spectrum colour at λ 5720, so it must be taken that at that point of the spectrum he begins to see colour, a point which is considerably lower than that given by his preliminary examination of the spectrum colour, and due, no doubt, to the fact that the white light used by the comparison light was that of the positive pole of the electric light. It seems probable that what C. called yellowish was really a sensation of white mixed with a very small quantity of red sensation (as he saw no yellow in the orange, in which that colour would be most easily distinguished on account of its luminosity), and red light, when strongly diluted with white light, to the normal eye appears slightly orange.

Subsequently C. was tested for the illuminating value of white light compared with my own and that of Mr. Nettleship. The apparatus used in this case (fig. 2) was, I believe, somewhat on the principle of Dr. Förster's photometer, with which I was unacquainted before I made the instrument. It is made as follows:—

FIG. 2.



E is a small tube for the eye to look down into a box 4 feet long; G is an aperture in the side of the box covered with ground glass; L is a gas-light; A rotating sectors which can be opened and closed at will; M a mirror to reflect the light on to a card (which can be changed at will, and on which are one or more black spots) slipping into a slot S from the top of the box. E is so arranged that the whole of the card can be viewed. The observer places his eye at E, and the sectors, which at first are closed, are gradually opened until the observer can see that there are black spots on a white ground. The angle of the aperture of the sector is noted. Each eye is tested.

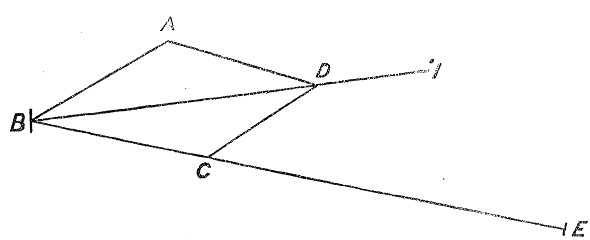
In this case my own right eye, agreeing with that of Mr. Nettleship, was used as the standard, since it was with that that the normal luminosity curve was originally made.

	Right eye.	Left eye.	Remarks.
Abney.....	17	17	5 smallish spots used as test object.
Alfred C...	31	25	,, ,, ,, ,,
Abney.....	10	9	1 large spot ,, ,,
Alfred C...	26	17	,, ,, ,, ,,

From this it may be concluded that C.'s appreciation of light to the standard is about half for the right eye, and two-thirds for the left that of the standard.

The horizontal colour field was tested by a modification of the colour patch apparatus.

FIG. 3.



A brass-work frame was made as shown, fig. 3. A and B are fixed to a board, the other arms are capable of moving with parallel motion, the arm BD slides through D; at B, and attached to BD, is a mirror which can be fixed in any position. The light, when once turned in

the direction BL, always falls on E, at the end of which a paper disc can be placed. A mirror without this arrangement can be employed, the light falling on a paper strip, but is not quite so convenient. The monochromatic light was thrown on the mirror, and the angular deviation from the zero point read, the eye being fixed on a point along the zero reading. The experiments were made first with the ordinary luminosity of colours, and subsequently with the reduced.

Scale No.	Wave length.	Temp. side.	Nasal side.	
56	6330	14°	10°	Square patch, 2-inch side.
52	5996	14	10	
47	5658	15	11	
56	5330	14	10	Small round spot, $\frac{1}{4}$-inch diam.
52	5996	14	10	
47	5658	white all over the field		
23	4600	sees blue throughout.		

In the above, the angles show where colour was first visible.

Case II.—The next two subjects are brothers (Alfred and William P., indicated below as P and Q), whose colour perception is monochromatic. Mr. Nettleship had previously tested them with wools, and the matches they made, such as matching yellow with blue, made it evident that their colour vision was very abnormal. The defect is not due to active disease, but they were born with it. They suffer from amblyopia. These cases were published as cases of "Day-blindness with Colour-blindness," by Mr. Nettleship, in the 'St. Thomas's Hospital Reports,' 1880 (vol. 10).

Testing them with the spectrum, they made most extraordinary mistakes, calling blue, red; red, green or blue. On cross-examination, it seems that they only distinguish colour by its luminosity; they always explain that one colour is lighter or darker than another; evidently their colour names are founded on the observation of what is told them as to the different colours, and not from any real knowledge of them. The next examination was to get their luminosity curve of the electric light spectrum, and this they did with the very greatest ease. Their readings for the same colour were occasionally a little erratic, differing as much as 5 per cent. from one another, but, by taking the means, their curves come out very concordantly Practically, the curves of the two brothers are identical, the means not differing 2 per cent. from one another at any part of the spectrum; hence it is unnecessary to give more than one of them. It should be mentioned that both brothers could just catch a glimpse of the red line of lithium when the spectrum of the vapour was on the focussing screen of the apparatus.

The luminosity curves are shown in the diagram, and the following is the table of observations :—

I.	II.	III.	IV.	V.	
Scale No.	Wave-length.	Luminosity to the normal eye.	Luminosity to P and Q.	$\frac{\text{IV.}}{\text{III.}}$	Remarks.
55	6242	66	1·2	0·02	"Both blue."
54	6156	84	2·4	0·03	
52	5996	97	9·6	0·10	
50·6	5990	99	14·4	0·145	(D line).
48	5720	95	33·6	0·35	"Both white."
46	5596	86	62·5	0·73	
44	5480	75	86·4	1·15	
42	5370	62·5	92·6	1·49	
40	5270	50	96	1·92	"Both white." (39·8, E line.)
38	5180	36	93·6	2·63	,, (38, "b" line.)
36	5080	24·5	86·4	3·38	
34	4990	15·0	77·4	5·16	
32	4910	8·5	60·0	7·06	
30	4820	5·5	41·0	7·45	"Both blue."
25	4650	2·5	21·6	8·64	
20	4510	1·4	9·6	6·85	
10	4270	0·6	2·4	4·00	

Their appreciation of light was—

	Right eye.	Left eye.
Abney	23	25
P	23	16
Q	15	15

We may take it that P's right eye has the same appreciation of light as the standard, and his left 1·5 times that of the standard. Q is 1·6 times that of the standard with both eyes. The luminosity curves were taken with both eyes open.

The curve is very remarkable, showing an intense excitement by the blue rays of the spectrum, the whole of which appears of one olour to both brothers. The maximum luminosity is about E, but

the place of the greatest difference in degree of luminosity, compared with the normal, is near F, where it is more than eight times more luminous than the normal eye. The area of their luminosity curve is 1800; that of the normal eye being 1650. If we take their appreciation of light as being 1·5 that of the standard, their luminosity curve should be 1650 by 1·5 or 2475. Theirs is 1800 as measured, the ordinates of their curve should therefore be multiplically 1·37 for a strict comparison with that of the normal eye. We may therefore take it that near F their sensation of light is 11·83 times that of the normal eye.

In the three patients we have cases of abnormal vision, one in which practically the only sensations in the central part of the eye are white and blue, and in the other two there is only one sensation. In these last two cases we have apparently a curve of the fundamental sensation, since it must be the same as the luminosity curve, and it appears to agree with that found by Koenig. In regard to Alfred C., it should be remarked that he begins to feel the blue sensation in the spectrum near the point where Koenig places its origin.

Addendum. Received June 18, 1891.

On Four Cases of Colour Blindness Examined for the Colour Vision Committee.

Case III.—The next case, W. S., is one of progressive atrophy of both eyes. When tested with spectrum colours—a patch of white light being placed in juxtaposition with the colour—it was found that he was absolutely blind to colour from 26·75 (λ 4733) on the scale of the spectrum to the termination of the red of his spectrum, which was close to 63 on the scale (λ 7082). Above scale No. 26·75 W. S. saw blue, and his spectrum was continued normally in the violet. Mr. Nettleship has promised to furnish a chart of his retina. His luminosity curve (fig. 4) was made without any difficulty, and, compared with my own, is slightly deficient, from the red to the yellow, but his perception of luminosity increases as the blue is approached.

The following is the table applying to his curve of luminosity :—

Scale No.	Wave-length.	Reading.	Remarks by W. S.
60	6728	3·4	Grey.
58	6520	15·0	,,
56	6330	41·0	,,
55	6242	43	,,
54	6152	69	
52	5996	94	
50	5850	100	,,
48	5720	96	
45	5538	88	
42	5373	74	
40	5270	61·5	,,
38	5172	45	
35	5042	30	
30	4848	12	,,
25	4675	6	Bluish.
20	4518	4	
15	4376	3	Blue.
10	4248	2·5	,,

He was subsequently tested with colour discs—Ultramarine (U), Red-royal (R), Emerald-green (G), Chrome-yellow (Y), White (W), and Black (B).

It was found that—

$$165\ (U) + 48\ (R) + 147\ (G) = 75\ (W) + 285\ (B).$$

The black reflected 3·4 of white; hence the true equation is—

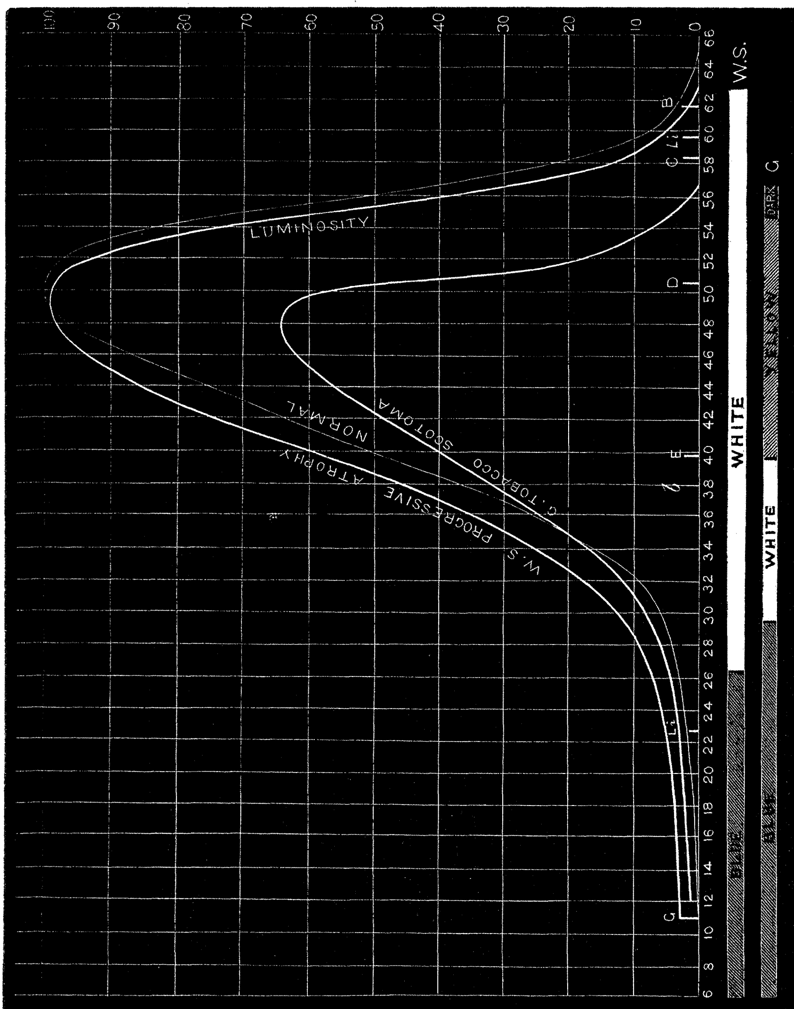
(i). $165\ (U) + 48\ (R) + 147\ (G) = 84{\cdot}7\ (W) + 275\ (B)$.
(ii). $120\ (U) + 240\ (Y) = 196\ (W) + 164\ (B)$ (corrected)—

With 260 (U) + 100 (Y) he sees blue.
250 (U) + 110 (Y) ,, light-blue.
242 (U) + 118 (Y) ,, no blue.

This last in connexion with (ii) shows that his blue perception is

neutralised by the yellow, although the yellow to him was matched with white.

FIG. 4.



The thin line curve is the normal curve.

Case IV.—The next case is that of G., suffering from very well marked tobacco scotoma, occupying a considerable area. His curve of luminosity of the spectrum is shown in fig. 4. The following table refers to it:—

Scale No.	Wave-length.	Reading.	Remarks by G.
57	6423	0	
55	6242	3	No colour.
53	6074	11	Colour "yellow," white "blue."
51	5919	34	" " " "
50	5850	60	" " " "
49	5783	64	Colour "gold," white "sky-blue."
45	5538	59	
40	5270	40	Both white.
35	5042	18	"
30	4848	10	"
29	4807	6	Colour "very pale blue," white as white.
26	4707	4	Colour "blue," white "white."
20	4518	3	" " " "
10	4248	2	" " " "

G. was tested for light sense in the apparatus described in the previous memorandum.

Light disappeared with

	Right eye.	Left eye.
Abney	5°	5°
Nettleship	5°	5°
G.	55·58·58	58·58

It thus appears that the final sensitiveness to light of the central part of the eye was nearly 12 times less than a person possessing normal sense.

Case V.—This was a remarkable case, which Mr. Nettleship had mentioned to the Committee. He had stated that this lady, N. W., mistook blue for red, and it was with some curiosity that this case was examined. Her first examination was as to colour sense with the spectrum colours, a patch of mono-chromatic light being placed in juxtaposition with an equal patch of white light. At 62·5 (λ 6890) of the scale the red of the spectrum disappeared. As the slit moved along the spectrum, and the white was approximately reduced to equal

luminosity, she described all the red as grey, and of the same colour as the white until 53·5 (λ 6110), and after this point she said the colour was brownish compared with the white. The colour continued of this hue to her till 48 on the scale (λ 5720), when she said the colour was neither brown nor green, but both. From 48 on the scale she described the colour as green till quite sharply at 31·5 (λ 4905). In the blue she again began to see grey; the grey at this end of the spectrum, and also of the white patch, she called brownish-grey.

Scale No.	Wave-length.	Reading.	Remarks by N.W.
62·5	7019	0	Both grey.
60	6728	3	,,
58	6520	10	,,
56	6330	30	,,
54	6152	52	Colour "brownish," white "grey."
52	5996	70	,, ,, ,, ,,
50	5850	81	,, ,, ,, ,,
48	5720	87	Colour "brownish-green," white "grey."
46	5596	90	Colour "green," white "grey."
44	5481	88	,, ,,
42	5373	82	,, ,,
40	5270	62·5	,, ,,
38	5172	46	,, ,,
35	5042	23	,, ,,
32	4924	12·5	,, ,,
31	4886	10	Colour "brownish-grey," white "brownish-green."
30·5	4862	8·5	,, ,, ,, ,,
25	4675	5	,, ,, ,, ,,
20	4518	3	,, ,, ,, ,,
15	4376	2·5	,, ,, ,, ,,
10	4248	1·5	,, ,, ,, ,,
0	4010	0·2	,, ,, ,, ,,

This name must evidently have been a mental distinction, as she described the red end and the white as grey only, and not brown-grey; and, indeed, she was tried again over that part of the spectrum, and adhered to the previous naming. It would appear to be due to the low luminosity which made the grey appear brownish to her, and not to any actual difference in hue.

Her curve of luminosity in the spectrum was next taken, and her readings are given in the table. The curve is shown in fig. 5. The shaded band beneath it applies to her curve. My own readings were 1/1·375 of the normal curve as shown in the diagram. The extinction of a gas-light, in my own case and that of Mr. Nettleship, was 13°·5. That of N. W. was 16°, showing that her final perception of light was 13·5/16 of what we may call the normal.

An endeavour was made to form a series of colour equations with her eyesight by placing three slits in different parts of the spectrum, but without success, although a match with white was made in two positions. One slit was placed in the orange-red at about 52 of the scale, another at E, and the third at G, and white light was formed, though her match was so erratic that it was useless to measure the apertures. When the slit in the violet was covered up, a white patch being alongside as a comparison, she called the mixture of red and green "brownish-green;" when the slit in the red was covered she called the mixed light of green and violet "green;" and when the green slit was covered up she called the purple colour a "different kind of brown."

When the first slit was moved into the red near the lithium line she called the colours "green," whenever the green slot was uncovered. A piece of signal-red glass (London, Brighton, and South Coast Railway) was placed in the white reflected beam, forming a red patch, and a patch of the blue scale at No. 30·5 (λ 4862) was placed alongside, and she matched them in luminosity and in colour. (The dominant colour of the signal glass in question was λ 6220.) She finally was tested with colour discs:—

One being in red with dominant wave-length	..	λ 6150
Another, emerald-green ,, ,,	..	λ 5373
And the third, French ultramarine ,,	..	λ 4700.

To make white she required

$$130\ G + 113\ R + 117\ U = 72\ W + 288\ B \text{ (corrected).}$$

She was then tried with the blue and green discs alone and made a match—

$$258\ U + 102\ G = 65\ W + 295\ B \text{ (corrected).}$$

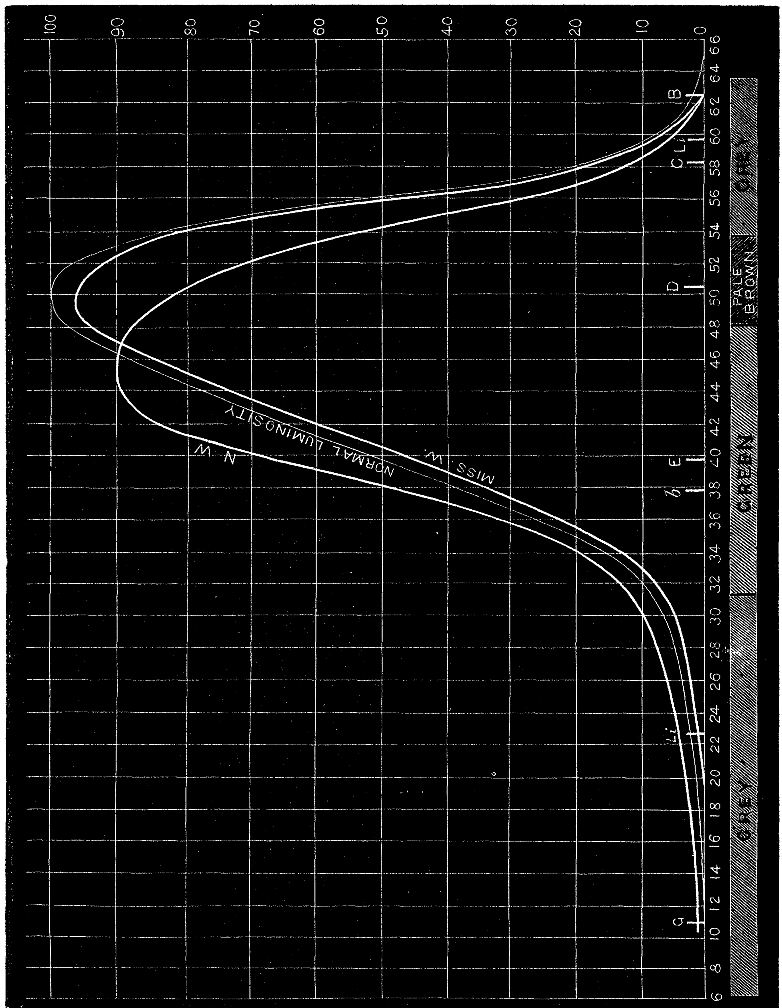
An attempt was made to match with the green and red discs alone, but this failed.

She matched the red disc alone with black and white, and also the blue disc alone—

$$360 \text{ R} = 56 \text{ W} + 304 \text{ B (corrected)},$$
$$360 \text{ U} = 60 \text{ W} + 300 \text{ B (corrected)}.$$

With any proportion of R and U mixed together she matched a grey of approximately the same intensity as above, as it might be supposed she would from the last two equations.

FIG. 5.



The thin line curve is the curve of luminosity for the normal eye.

Taking the intensity curve of the light reflected from the red it was found to contain a great deal of the part of the spectrum which she called brownish, viz., from 53·5 to 48 on the scale, whereas the blue reflected a trifle of this portion of the spectrum, as did also the green, and this may account for her making a match to grey of U and G, and not of R and G, but it is hard to see why she matched U alone and also R with the grey.

Reviewing the case, it seems that any perception of colour is very small, and that the sensations are green and red, together with white. Experiments which I have described in my book on "Colour Measurements and Mixture," 1891, show that a large proportion of colour may be mixed with white without being perceived, but this colour so hidden has still the capability of neutralising a certain quantity of the complementary colour thrown on the white, which, by itself, would not be masked by the white. It would seem then that in N. W.'s case the two colours perceived were very much diluted, and at parts of the spectrum so diluted as not to be perceived, but that the latent colour, if it may be so called, has the power of forming a grey with the green which she sees more strongly.

Case VI.—This case is that of Miss W., who was brought before the Committee by Dr. Lindsay Johnson, on April 29. The right eye was apparently normal for colour, but with the other she saw nothing but shades of white.

Miss W., it appears, has had a slight stroke of paralysis, which affected her left side, and subsequently she discovered that colour sensation in the left eye had disappeared. Mr. Brudenell Carter, the day after the meeting of the Committee, examined her and pronounced hers to be a case of atrophy of the optic nerve.

I examined her with the spectrum colours on the 5th May, and found her left eye totally blind to every colour, though her perception of light was very fair. She had very little difficulty in comparing the luminosity of the most brilliant spectrum colours with the white patch of light placed alongside them. In making the measurements she experienced a certain amount of fatigue, but, by resting the eye for short intervals, her readings were very constant. The following is the table of her readings:—

Scale No.	Wave-length.	Readings.	Remarks by Miss W.
63	7082	0	Both colour and white patch appeared as white throughout the spectrum.
62	6957	1	
60	6728	7	
58	6520	18	
57	6423	28	
56	6330	43	
54	6152	76	
52	5996	90	
50	5850	95	
48	5720	93	
46	5596	83	
44	5481	71	
42	5321	58	
40	5270	46	
38	5172	32	
36	5085	21	
34	5002	12·5	
32	4924	7	
30	4848	4·5	
28	4776	3·0	
25	4675	1·5	
20	4518	0·4	
19	4488	0·0	

At 19 the light perception was so diminished that she could not match the grey. Her light perception extended further into the violet (as white) beyond this point, as the subsequent measures show conclusively.

It seemed that it would be interesting to examine her eye for the extinction of light by the same method as that described in my recent paper.

The orange sodium light of the spectrum was thrown on the apparatus therein described, of a luminosity of an amyl lamp 1 foot off, and the slit giving this brightness remained unchanged throughout the examination, and was moved through the spectrum till a position was reached where all light was just extinguished. Her perception of the point of extinction was very acute. Rotating sectors were placed in front of the apparatus, as described in the paper referred to, set at different angles, so that the amount of reduction of the luminosity of the spectrum was known at once.

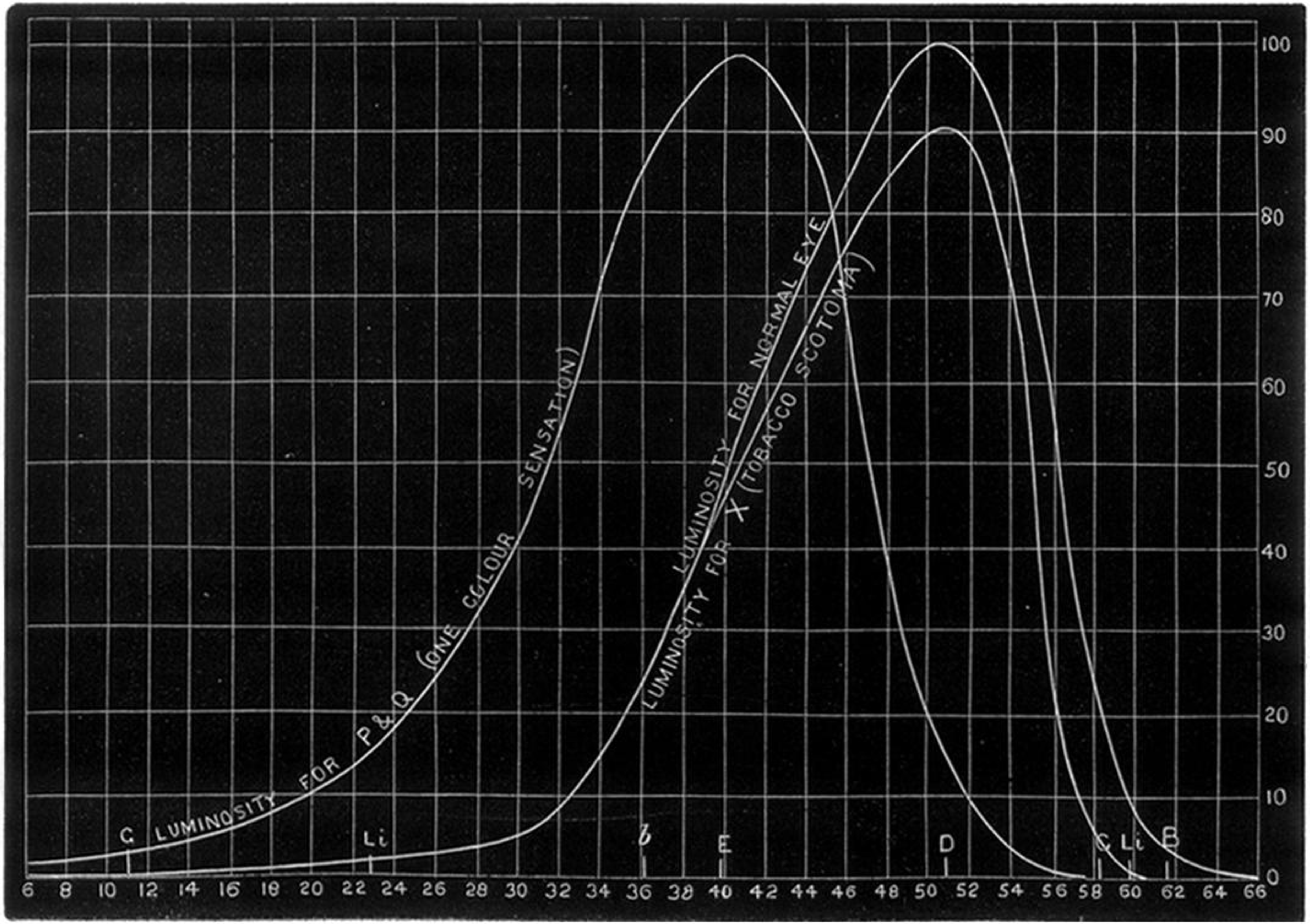
Scale readings of light extinction.

Light coming through the slit reduced to—	Slit moved towards the violet.	Slit moved towards the red.
No reduction.	15	53·7
$\frac{1}{2}$ intensity.	20·7	52·4
$\frac{1}{4}$ "	21·7	50·9
$\frac{1}{9}$ "	23·2	48·7
$\frac{1}{18}$ "	26·7	46·7
$\frac{1}{36}$ "	34·7	44·2
$\frac{1}{45}$ "	—	40·0

The extinction of light with the full aperture to myself was at 2·1 and 57·9. At 57·9 the luminosity of the spectrum is 0·22 that at the D line, and as the light on the screen at the end of aperture is 1/620 that falling on the instrument originally, it follows that the extinction to myself was when the light of 57·9 (λ 6510) was 0·22/620 = 0·000355 of an amyl lamp placed at 1 foot from the screen. These details are given to show that the newer instrument used in these tests gives the same results as the older one, for with the latter it was 0·000350.

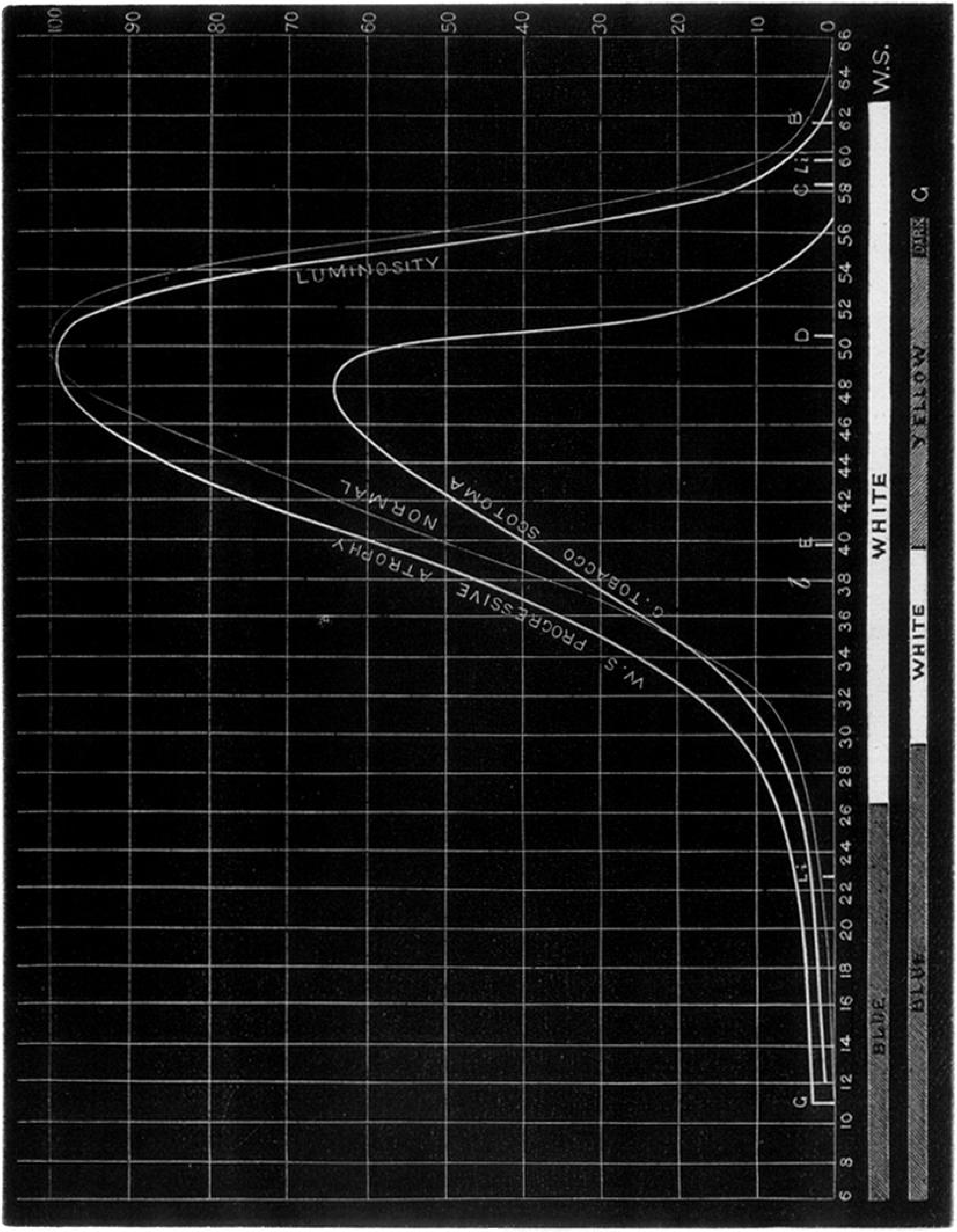
The place in the spectrum where Miss W. last perceives light is the same as my own. The luminosity which is invisible to her is when 1·45/100,000 of an amyl lamp illuminates a screen 1 foot off. At D if 71/100,000 of an amyl lamp illuminated a screen 1 foot off it is invisible to her. With my own vision if the screen be illuminated with 7/100,000 of the same light it just becomes invisible. There is therefore a marked difference between the two sights as regarding initial perception of light.

Fig. 1.



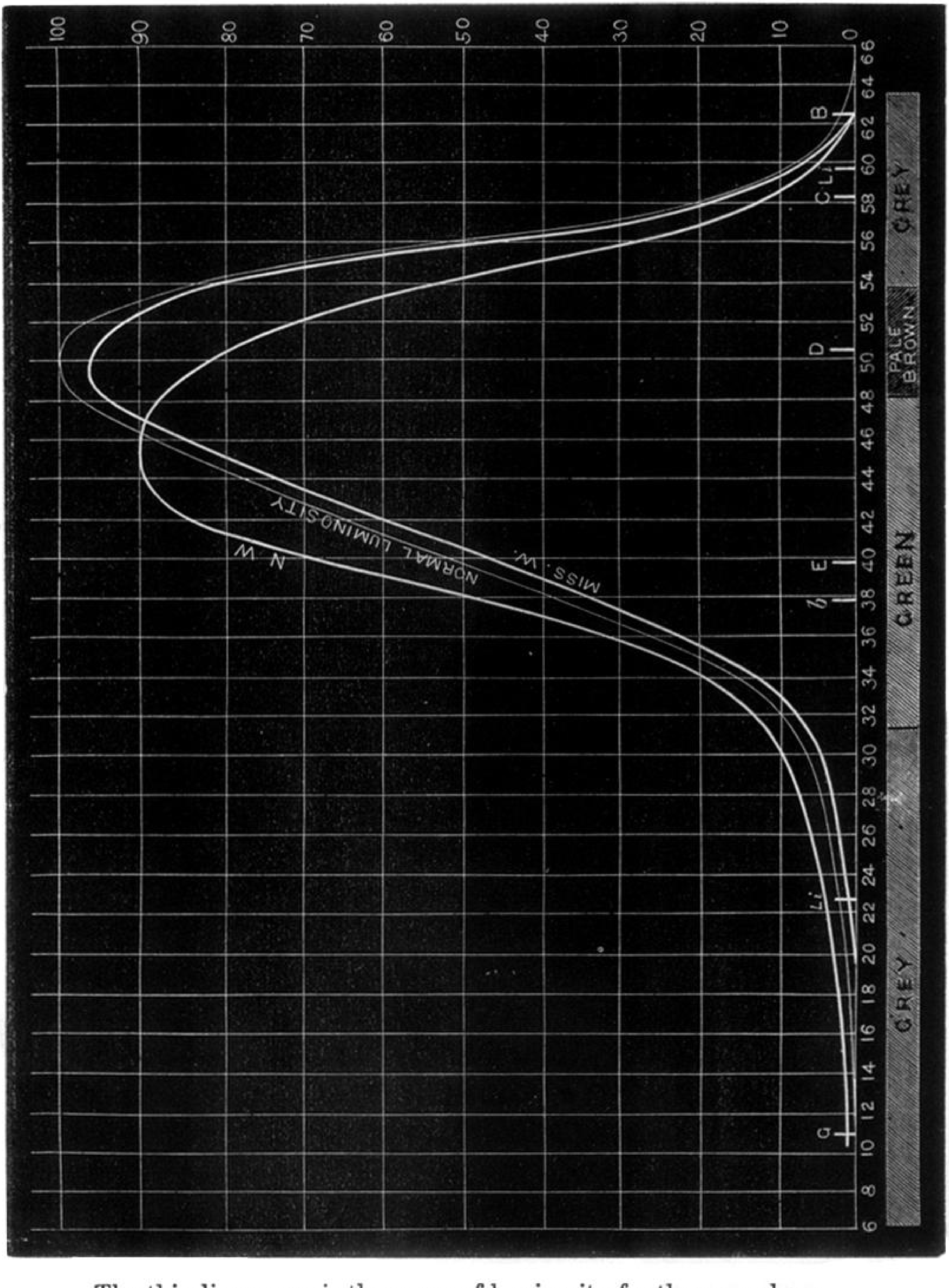
LUMINOSITY FOR P & Q (ONE COLOUR SENSATION)
LUMINOSITY FOR NORMAL EYE
LUMINOSITY FOR X (TOBACCO SCOTOMA)
G
Li
b
E
D
G Li B
6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44 46 48 50 52 54 56 58 60 62 64 66
100 90 80 70 60 50 40 30 20 10 0

FIG 4.



The thin line curve is the normal curve.

FIG. 5.



The thin line curve is the curve of luminosity for the normal eye.